Postoperative Parenteral Nutrition

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• Parenteral feeding is not an adequate substitute for oral feeding. Water and electrolytes can readily be supplied parenterally, but not all necessary nutrients. To provide the 2,000 to 2,500 calories per day needed for adequate energy and to avoid oxidation of protein, concentrations of dextrose as great as 25 per cent with an additional 5 per cent of ethyl alcohol have been used parenterally with success. Fat emulsions have been given intravenously with some success, but undesirable reactions in as many as 16 per cent of patients have been reported. Protein may be given as amino acids in solution with 10 to 15 per cent dextrose. Water-soluble vitamins may be lost through diuresis if administered intravenously; of these vitamin C is necessary to healing of wounds and appears to have special value in reactions to stress. If fat nutrition is impaired, deficiency in fat-soluble vitamins is to be expected; of these, vitamin K is important to production of prothrombin and therefore especially necessary to recovery from operation or injury.

AMONG THE CONDITIONS retarding postoperative convalescence in which the importance of nutritional deficiencies has been emphasized in recent observations are retarded wound healing,[5] decreased resistance to infection,[16] anemia, increased susceptibility to hemorrhagic shock,[8] and reduction in the activity of enzymes.[2] Such deficiencies may be the result of prolonged dietary inadequacy or of recent nutritional impairment occasioned by acute illness. Moreover, certain operations impose physiological stress which increases the nutritional needs of the patient at a time when oral feeding is contraindicated or is inadequate. Water and electrolytes can be readily supplied parenterally, but not all necessary nutrients can be. Care must be taken, therefore, to detect nutritional deficiencies early and correct them promptly. It is with supplying the nutritional elements that are more difficult to administer than water and electrolytes that this presentation is concerned.

Special nutritional regimens are indicated for patients undergoing multiple operations, in order to counteract the catabolic effect of the procedures. Resumption of special nutritional measures may be needed in event of relapse. Application of a sound nutritional plan will prevent in part the loss of weight and physical debility which often occur in early convalescence from injury or disease. However, it is necessary also to avoid preventable loss of blood or faults in operative technique which may complicate the nutritional problem, for even the most thorough postoperative measures are not adequate to compensate for them. The early resumption of normal eating is the most important factor in maintaining the patient's nutrition.

Nutritional requirements include six major components of the diet: Water, minerals, carbohydrates, fats, proteins and vitamins. Carbohydrates, fats and proteins are sources of energy (calories) and provide for growth and repair of tissues. Water, minerals and vitamins do not yield energy, but are essential elements of the chemical mechanisms for the utilization of energy and for the synthesis of various essential metabolites such as hormones and enzymes. The minerals are also incorporated into the structure of the tissues and, in solution, play a role in water metabolism and acid-base equilibrium as well as in other important aspects of metabolism.

Caloric requirements. Energy for physiological processes is provided by the combustion of carbohydrates, fats and proteins, but carbohydrates and fats are physiologically the most economic sources. Proteins serve primarily to provide for tissue growth and repair but it is important to emphasize that they too are metabolized for energy if the caloric intake from other foods is inadequate. Normal, healthy adolescents or adults at rest require 25 calories per kilogram of body weight per day (approximately 1,600 calories); young infants, 60 calories per kilogram; older infants, 55 calories per kilogram; children, 30 calories per kilogram per day. During periods of growth or convalescence extra calories are needed. In special circumstances such as infection accompanied by elevated temperature, or in heightened metabolism from any cause

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the caloric demand is further increased. These factors raise the maintenance caloric requirements for adolescents and adults to 30 to 35 calories per kilogram per day (2,000 to 2,500 calories).

Carbohydrate requirements. Carbohydrates are depended upon as an immediate source of energy, but the ability of the body to utilize parenterally administered sugar is limited. According to Lockhart and Elman[6] it is usually not desirable to infuse dextrose intravenously at a rate exceeding 0.5 gm. per kilogram of body weight per hour, since considerable glycosuria, diuresis and consequent dehydration are likely to result. As the usual solution of dextrose—50 gm. per liter—supplies only 200 calories per liter, more concentrated solutions have been tried and found to be well tolerated if administered very slowly. Spencer and Beal[11] reported that in trials with a 25 per cent solution of dextrose 93.8 per cent was retained and that the risk of phlebitis at the site of infusion was "minimal." They administered the solution at a rate of 40 to 60 gm. per hour, a faster rate than that recommended by Lockhart and Elman. None of the subjects in their studies, however, was in the immediate postoperative period.

The use in parenteral nutrition of so-called "invert sugar," which is a mixture of dextrose and fructose prepared by the hydrolysis of cane sugar, has recently been investigated.[4, 12, 13, 14] Proponents of invert sugar believe that it is more efficiently utilized than an equal quantity of dextrose, but in practice the difference does not seem to be significant.

Ethyl alcohol, which supplies about 5.6 calories per gram, is sometimes added to solutions for parenteral administration, but as the capacity of the body to utilize alcohol is limited and the cumulative effects may be undesirable, alcohol should be used in concentrations no greater than 5 per cent, and only in combination with dextrose. Spencer and Beal[11] added 5 per cent alcohol to 25 per cent of dextrose in the solution used in their studies, which was equivalent to 1,280 calories per liter.

Fat requirements. As fats have a caloric value (9 calories per gram) more than twice that of carbohydrates or proteins, methods of parenteral administration have been carefully explored. Although fat emulsions have been given intravenously with generally satisfactory results, there are several obstacles to widespread use of them. The preparation of a reproducible, pyrogen-free emulsion which remains stable in storage has not yet been achieved. The incidence of reactions to lipid infusions was as high as 16 per cent in the experiments of Shafiroff and Mulholland.[10] These reactions included headache, chills, nausea, vomiting and fever. The fever may be a "thermogenic reaction" to injection of fat at a rate which exceeds the capacity of the body to utilize it. Orally administered fat is normally stored in fat depots and slowly oxidized in accordance with the needs of the body. It is possible that if large quantities of fat are given intravenously, storage cannot be adequately accomplished and consequently rapid oxidation occurs, with resultant evolution of excessive heat.[3] This hypothesis is supported by the occurrence of ketonemia during the infusion of fat.

No notable damage to the liver, spleen or kidneys has been ascribed to the use of fat emulsions.

Protein requirements. In addition to the minimal protein required for regular replacement of tissue, the amount needed in postoperative convalescence, although highly variable, may be safely assumed to be greater than the normal daily requirement of 1 gm. per kilogram of body weight—in some patients 2 to 4 gm.[1, 15] Furthermore, if the "sparing action" of non-protein sources of energy is not adequate—that is, if these sources do not provide the full energy requirement of the body—protein is converted into energy rather than used for tissue synthesis. For example, Riegel and co-workers[9] found that in the immediate postoperative period a daily intake of 130 gm. of protein and 2,000 calories was needed for positive nitrogen balance.

As previously indicated, the usual regimen of parenteral nutrition does not provide sufficient calories; the parenteral administration of amino acids, therefore, has not proved to be an adequate method of maintaining protein requirements. For effective use, amino acids must be given in a solution with 10 to 15 per cent dextrose. Three liters of such solution with 5 per cent amino acids would approach the recommended intake of protein and calories. As such a solution is hypertonic, and as amino acids must not be administered at a rate faster than 50 gm. in four hours, the solution must be given very slowly. These factors greatly limit the usefulness of parenterally administered amino acids. However, in view of the well-documented need for individual amino acids in a variety of important metabolic functions other than protein synthesis, it would seem that when parenteral nutrition is needed for more than two or three days, at least 50 to 100 gm. of amino acids per day might well be added to the nutritional regimen.

Vitamin requirements. It is unnecessary to give vitamin preparations routinely after operation, although such supplementation is of course advisable both before and after operation if there is evidence of preoperative deficiency. Vitamins should also be given during convalescence complicated by mal-

nutrition, by decreased utilization of vitamins, by acceleration of metabolism as in fever and infection, or by reaction to stress.

Normal losses of water-soluble vitamins are increased by the diuresis that follows administration of parenteral fluids. The recommended daily postoperative doses of the most important of these vitamins are: thiamine (B_1), 5 to 10 mg.; riboflavin (B_2), 5 to 10 mg.; nicotinic acid (niacin), 50 to 100 mg.; ascorbic acid (vitamin C), 100 to 250 mg. As the loss of water-soluble vitamins in the urine is considerable when they are administered intravenously, it is preferable to inject them intramuscularly or subcutaneously if they cannot be taken by mouth.

There is much evidence that vitamin C has a special biochemical function in the reaction of the body to stress such as toxic infection, fever, burns and other trauma. It is also directly involved in the healing of wounds. In certain cases, therefore, a daily intake of 500 to 1,000 mg. of vitamin C may be indicated.

Deficiencies in fat-soluble vitamins are to be expected if there is any defect in fat digestion or absorption. Most important in this regard is a deficiency of vitamin K, which leads to hypoprothrombinemia with consequent delay in the rate of blood clotting. In this condition it is necessary to raise the prothrombin level to at least 60 or 70 per cent of normal. Vitamin K should be given intramuscularly both before and after operation, usually 4 mg. daily. It should be remembered that vitamin K deficiency is not always accompanied by jaundice.

When nutrition is limited to parenteral feedings or when the food intake is restricted for a long time, it is probable that, in addition to the vitamins already recommended, vitamin A (5,000 to 10,000 units), pyridoxine (B_6) (2 mg.) and pantothenic acid (20 mg.) will be needed daily.

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